Applications of the Soil-Ecological Survey of Denali National Park and Preserve

by Mark Clark

Abstract

A soil and ecological survey of Denali National Park and Preserve (Denali) was completed by the Natural Resources Conservation Service in 2004 *(Clark and Duffy 2004)*. Products included digital maps, tabular soils information, a detailed soils report, as well as a database with 2,100 field stops. This soil-ecological survey is a multi-disciplinary effort that incorporates soil, hydrologic, and vegetation information into a variety of products. This baseline information is fundamental to an understanding of the natural resources of Denali and provides a critical element for land use decisions on national park lands.

Application of the survey information includes basic distribution maps for a variety of natural resources such as soils with permafrost, wildlife habitat, prediction of fire-prone areas, surficial geology, landforms, and identification of plant communities that are likely to have rare and endangered plant species, to mention a few. Three examples of specific application of survey products are provided. The first example illustrates basic distribution maps of soils with permafrost within three feet (1 m) of the soil's surface. The second example illustrates the modeling capabilities of the information. In this example, soils with permafrost have been categorized based on sensitivity to surface disturbance or increasing air temperatures associated with regional climate change. The final example illustrates the distribution of soil map units that support a plant community with a plant rarely observed in the park, Selkirk's violet *(Viola selkirkii)*.

Introduction

USDA-Natural Resources Conservation Service (NRCS) completed a soil-ecological site inventory for Denali National Park and Preserve in 2004 *(Clark and Duffy 2004)*. The project provides detailed digital soil maps at 1:63,360 scale and tabular documentation as well as descriptive information of soil, vegetation, and ecological sites. A map based ecological hierarchy based on ECOMAP *(Bailey et al. 1994)* provides park-wide ecological information at a variety of different landscape resolutions. Products provided include a comprehensive set of soil and vegetation field data from over 2,100 points that were entered into a Microsoft Access database and a variety of GIS general theme maps that include hydric soils, vegetation, permafrost, landforms, and soil processes. Products are available on-line at the NRCS web soil survey website: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey. aspx

The spatial and tabular data and manuscript jointly provide baseline soil and vegetative resource information that serves as basic resource information for Denali. Landscape modelers may use the data to establish areas of critical wildlife habitat, answer watershed issues, better understand the potential uses and limitations of soils, and illustrate the distribution of plant communities as well as individual plant species in Denali. Researchers can extrapolate their research to similar landscapes elsewhere by tying research to specific ecological sites.

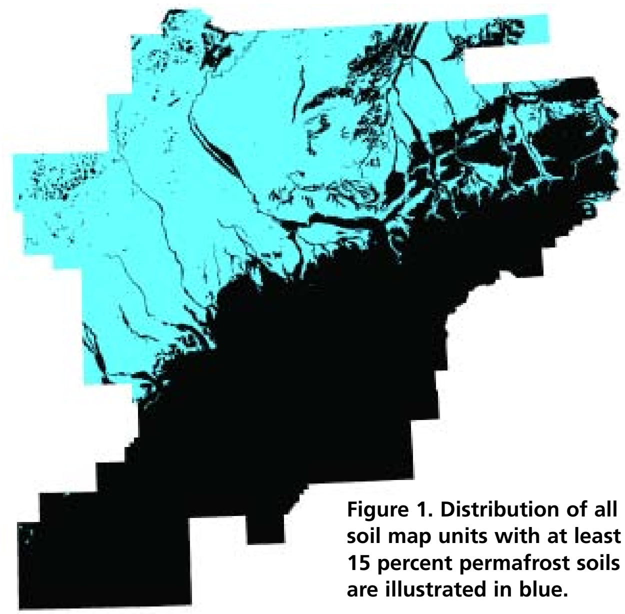

Figure 1. Distribution of all soil map units with at least 15 percent permafrost soils are illustrated in blue.

Application Examples

Specific applications of the survey products are described below. Figures 1 and 2 illustrate the distribution of soil map units with permafrost soils using two slightly different criteria. Figure 1 illustrates map units containing soil components with permafrost that comprise 15% or more of the map unit. The total distribution of map units that meet these criteria encompasses 2.3 million acres or about 38% of the park. Figure 2 illustrates the distribution of map units with varying percentages of soils with permafrost based on four categories: those containing no soils with permafrost; those containing 1-14% soils with permafrost, those containing 15-79% soils with permafrost; and those containing 80% soils with permafrost. Total acreage for the second example is slightly higher due to the addition of soil map units with less than 15% permafrost.

The next example is the modeling of the loss of permafrost from soils based on soil sensitivity to surface disturbance or increasing air temperatures associated with regional climate change. Permafrost is sensitive to changing surface soil temperatures with changing site characteristics such as changing regional climate, vegetation, and snow cover *(Osterkamp and Romanovsky 1999)*. Soil characteristics such as the amount of organic mat disturbed and soil texture are also important in determining the persistence or loss of permafrost following fire. Soils with a high sand and rock fragment content conduct heat effectively and are most likely to experience significant lowering of permafrost. Conductivity of heat increases in soils as particle sizes increase *(Jury et al. 1991)*. A crude model consisting of three categories of sensitivity based on these thermal soil properties is described and illustrated below.

Soils described as highly sensitive are those that warm rapidly and have an associated subsidence or thawing of permafrost *(Figure 3)* following significant reduction in the thickness of the surface organic mat as a result of fire. These soils consist of less than 3 feet (1 m) of loamy alluvium over sandy and gravelly alluvium on terraces and alluvial fans. Permafrost drops below 6.5 feet (2 m) of the ground surface within one to three years following fire.

Soils with permafrost are described as moderately sensitive to a reduction in the organic mat thickness as a result of wildfire *(Figure 4)* based on the following criteria. Soils are loamy throughout with 10-35% rock fragments in the upper 3 feet (1 m) of soil. These include soils on till plains, all positions on glaciated low mountains, and on lower mountain slopes of non-glaciated mountains. These soils have intermediate levels of thermal conductivity attributed to the moderate level of rock fragments and loamy soil matrix, which conducts heat at a slower rate than soils of the first group. Loss of permafrost below 6.5

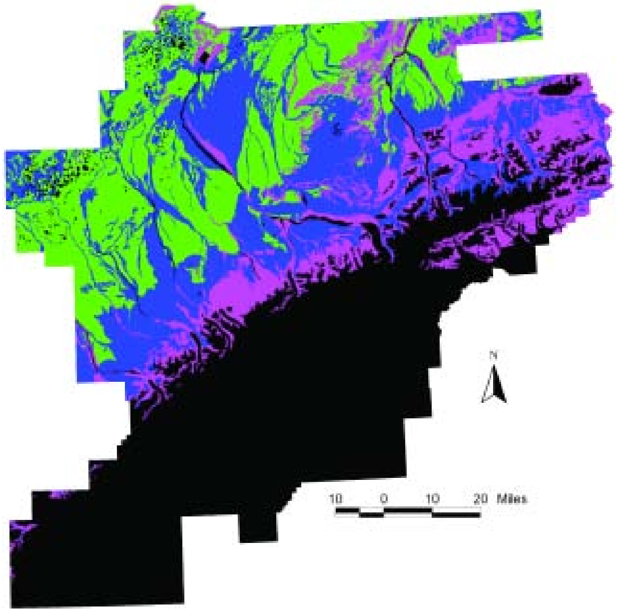

Figure 2. Distribution of four categories of soil map units with permafrost soils including; (black) no permafrost, (pink) 1 to 14 percent, (blue) 15 to 79 percent and (green) 80-100 percent of the unit consists of permafrost soils.

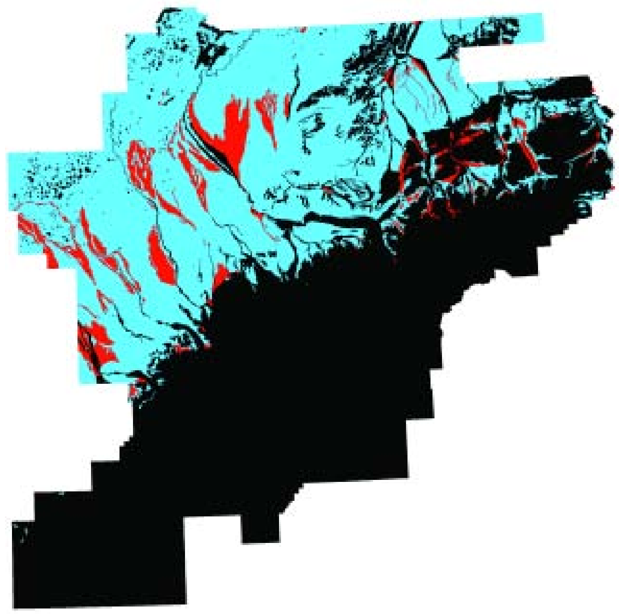

Figure 3. Soils with permafrost that are highly sensitive to disturbance or temperature change are represented in red and total 292,042 acres or about four percent of Denali. Blue areas represent soil map units consisting of over 15 percent permafrost soils.

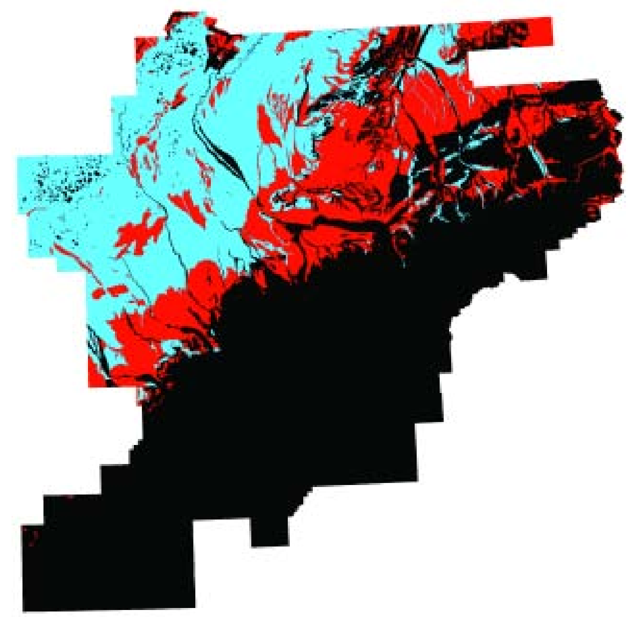

Figure 4. Soils with permafrost that are moderately sensitive to disturbance or temperature change are represented in red and total 1,100,094 acres or 18 percent of Denali. Blue areas represent soil map units consisting of over 15 percent permafrost soils.

feet (2 m) within three to five years following fire is commonly observed.

Soils with permafrost that are considered to have a low sensitivity to thaw after fire *(Figure 5)* are based on the following criteria. Soils consist of rock-free silty or loamy materials over 3 feet (1 m) thick on loess mantled plains, hills, and terraces. The relatively fine textured surface layers have low thermal conductivity properties and therefore a slower temperature change following fire or other surface disturbance. Lowering of permafrost in the soil profile occurs following disturbance; however, lowering below a depth of 6.5 feet (2 m) is rare unless associated with massive ice degradation.

Extrapolation of research to areas of similar ecological site or habitat is provided in the final example. Selkirk's violet *(Viola selkirkii)* occupies a very limited habitat along the southern part of Denali National Park and Preserve and is considered rare. The frequency of occurrence ranges from 9-14% of field stops (29 of 301) in favored habitats in the southern part of the park. Plant communities associated with the occurrence of Selkirk's violet include Barclay willow/herbaceous meadow mosaic, Sitka alder/tall herbaceous meadow mosaic and riparian poplar and riparian alder types. By linking Selkirk's violet to these favored communities and associated ecological sites a spatial representation can be created of areas where the probability is high that Selkirk's violet may be observed *(Figure 6)*.

Summary

The soil-ecological survey of Denali National Park and Preserve provides a spatial representation of soil and vegetation resources of the area. This information is valuable to resource planners in terms of understanding soils, vegetation, hydrology, and landforms of the area. Researchers may use the information as a tool to extrapolate research to similar ecological sites throughout Denali National Park. Modelers will find the various soil properties and vegetation attributes of the data useful in understanding habitat patterns and their extent as well as identifying environmentally unique and sensitive areas.

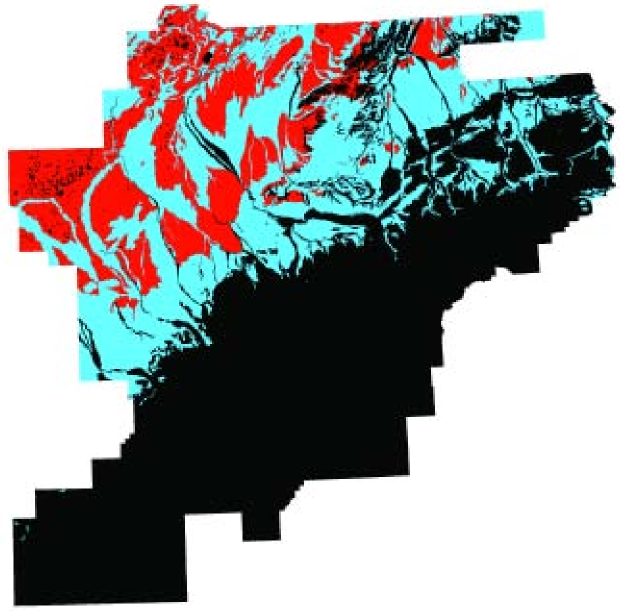

Figure 5. Soils with permafrost with low sensitivity to disturbance or temperature change are represented in red and total 968,061 acres or about 16 percent of Denali. Blue areas represent soil map units consisting of over 15 percent permafrost soils.

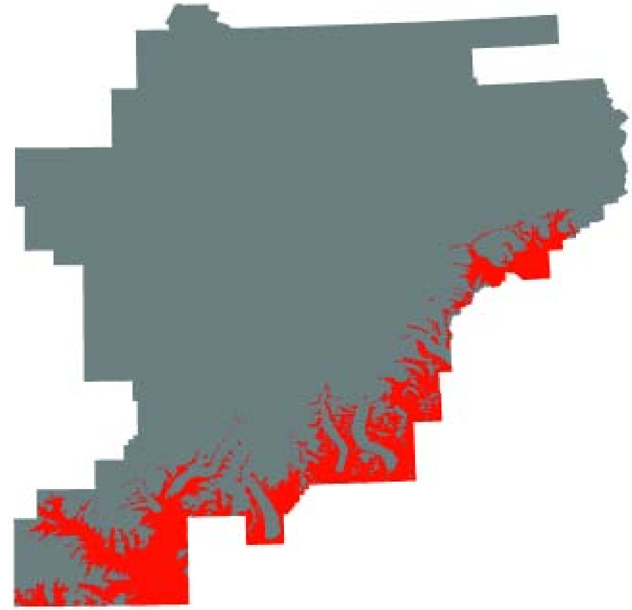

Figure 6. Distribution of soils and plant communities associated with the occurrence of Selkirk's violet is represented in red.

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